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Developing a Consumer Product Safety Check Tool for Mobile Devices

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<p>This Master's thesis focuses on creating a proof-of-concept version of a mobile application, where consumers can easily check the most relevant safety related issues of a consumer product. In addition, the application includes functions designed to assist the market surveillance activities of the Finnish Safety and Chemicals Agency Tukes.</p> <p>The literature review focuses on determining the current knowledge related to and influencing the usability of software applications, the effectiveness of information and furthermore, the aspects influencing the safety education.</p> <p>The current consumer behavior regarding the knowledge about product safety and safe use of consumer products was studied by conducting a quantitative questionnaire study, in which respondents represented the adult Finnish population with three percentage point margin of error at 95 percent confidence level.</p> <p>The current product safety components of consumer products were examined generally, and in two example contexts, by analyzing the relevant laws, regulations and standards.</p> <p>Based on the knowledge obtained from the literature review and the current state analysis, a proof-of-concept version of a mobile application was developed, which includes the following three different functions; 1. enables consumers to easily send notifications to Tukes, 2. enables consumers to check if a specific product is deemed dangerous or non-compliant by authorities and 3. includes product safety related information of consumer products.</p> <p>The usability of the proof-of-concept version of the mobile application was validated by qualitative focus group discussion session, from which suggestion for further development was also gathered.</p> <p>The usability of the proof-of-concept version of the mobile application was validated by a discussion session of a qualitative focus group, from which suggestions for further development were also gathered.</p>	
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Helsinki, November 12, 2018

Jyri Pekkanen

Contents

1	Introduction	1
1.1	Overview	1
1.2	Business Challenge	2
1.3	Case Organization	2
1.4	Objective, Scope and Outcome	3
1.5	Thesis Outline	4
2	Method and Material	5
2.1	Research Plan	5
2.2	Data Collection and Analysis	6
3	Literature	8
3.1	Aspects influencing software application usability	9
3.1.1	Aesthetic graphics	9
3.1.2	Color	10
3.1.3	Control obviousness	10
3.1.4	Entry point	10
3.1.5	Fingertip-size controls	11
3.1.6	Font	11
3.1.7	Gestalt	12
3.1.8	Hierarchy	12
3.1.9	Subtle animation	12
3.1.10	Transition	13
3.1.11	Loading time	13
3.1.12	Reliability	13
3.2	Implementation of the aspects influencing software application usability	14
3.3	Aspects influencing information effectiveness	14
3.3.1	Amount of information	14
3.3.2	Type of information	14
3.4	Aspects influencing safety education effectiveness	15
3.4.1	The amount of education material	16
3.4.2	The type of education material	16
3.5	Conceptual Framework	17
4	Current state analysis	17

4.1	Current state of consumer behavior regarding product safety	17
4.2	Key findings of consumer behavior regarding product safety	25
4.2.1	Knowledge and behaviour regarding market surveillance	26
4.2.2	Consumers' knowledge of warning symbols	27
4.2.3	Consumers' need for education and information	28
4.3	Product safety components in general	29
4.4	Product safety components in two example contexts	29
4.4.1	Candles	31
4.4.2	Cigarette lighters	32
4.5	Summary of current state analysis	34
5	Creation of the proof of concept version of the tool	35
5.1	Conceptual design	35
5.1.1	Information and Education	37
5.1.2	Functional design	37
5.1.3	Visual design	38
5.2	The proof-of-concept version of the application	39
5.2.1	Create notification	39
5.2.2	Notification check	40
5.2.3	Product safety information section	43
5.3	Summary of application development	55
6	Small scale product validation	56
6.1	Feedback from Single Focus Group discussion	57
6.2	Proposals for further development	58
7	Discussion and Conclusions	58
7.1	Summary	58
7.2	Next practical steps towards implementation of the application	59
7.3	Evaluation of thesis trustworthiness	59
	References	64

1 Introduction

1.1 Overview

The vast amount of different types of consumer products in the marketplace today is expanding in a rate never seen before. It is no longer possible for an average consumer to know all relevant matters concerning product safety of all types of products in the marketplace. As a result, consumers should be able to easily check the most relevant safety features of a product prior to purchase decision, fast and easily where ever they are. Currently the relevant information is simply too hard to find, as it is scattered all over.

The ANALYTICAL REPORT ON CONSUMER PRODUCT SAFETY (Organisation for Economic Co-operation and Development, 2009) prepared to facilitate the OECD Committee on Consumer Policy's Roundtable on Consumer Product Safety discussion in 2008 recognized this issue, and stated the following:

Markets are generally believed to work best when consumers can act rationally in their best interest, based on symmetric information and competitive markets. On this basis, consumer demand determines which products succeed or fail. However, for this to be true, consumers would need to know about the potential harmful consequences resulting from using products that present an unreasonable risk. But consumers have great difficulty in assessing the relative safety of products, due to information asymmetries, which means that consumers often have no way of 'rationally' assessing the safety of products beyond trusting that they are safe. The role of consumer product safety regulation is to address actual and potential market failures.

The growing number of products in the marketplace is also a rising concern in market surveillance agencies, as it is increasingly more difficult to supervise the safety of all types of products in the marketplace. Most agencies have seen budget cuts to their operations in the past years due to global recession, and thus they have to rely more and more on risk-based market surveillance systems (instead to large numbers of product testing etc).

In its market surveillance, Tukes relies greatly on getting notifications from consumers about products that have caused accidents or the consumer suspects to be dangerous or non-compliant with relevant regulations. The consumer notifications are a crucial part

of Tukes' market surveillance, and the more accurate the notifications are, the more impact they have on Tukes' ability to do risk-based market surveillance.

Finnish consumers' trust in product safety is among the highest in the EU. As much as 81 % of Finnish consumers think that most products on the market are safe. Compared to EU average of 78 % the number is significant (European Commission, 2017). This is probably due to the fact that product safety has been a high concern for Finnish authorities and the long-term working for product safety concerned issues has paid off (verkolehti.tukes.fi, 2015). Consumers' trust regarding product safety in general can be seen as a positive thing, as it is likely to mirror the general safety of the products in the marketplace, but it can also create some negative effects in the rapidly changing consumer product environment. Should consumers grow too accustomed to relying blindly on the product safety, they will likely fail to check the safety of a product they are acquiring, which can cause more accidents.

1.2 Business Challenge

As explained above, it is increasingly more difficult for consumers be aware of all the necessary product safety features of all types of products in the ever-expanding market. All the information about product safety related issues is scattered all over, and thus it is difficult for consumers to find relevant information about any given product they are thinking of purchasing or using for the first time. It is, therefore, crucially important that market surveillance agencies develop different, more easily accessible ways for consumers to find relevant safety features of consumer products compiled in a single source.

1.3 Case Organization

This research project is conducted for Finnish Safety and Chemicals Agency (Tukes). Tukes is a government agency operating under several Ministries, the Ministry of Economic Affairs and Employment is in charge of the ministerial governance and supervision of Tukes (Tukes.fi, 2016). According to Act of Safety and Chemicals Agency (laki turvallisuu- ja kemikaalivirastosta 1261/2010) Tukes is responsible of supervising and promoting, among other fields, the safety and compliance of consumer products.

Tukes employs some 250 professionals.

Tukes is divided to four different Departments; The Chemicals Department, The Industrial Department, The Products Department, FINAS Finnish Accreditation Service and The Department for Information and Development.

This applied research project is made primarily for the Consumer Product Unit that operates under Products Department and is possibly widened to serve other Departments and Units in the future.

The Consumer Product Unit is responsible of the market surveillance of consumer products that fall under the scope of the following European Parliament Directives;

Directive 89/686/EEC - Personal Protective Equipment

Directive 2001/95/EC - General Product Safety

Directive 2006/42/EC – Machinery

Directive 2009/48/EC – Toy safety

Directive 2009/142/EC – Gas appliances

1.4 Objective, Scope and Outcome

The amount of different types of products in the market today is extremely vast. It is virtually impossible for an average consumer to be aware of all relevant safety features of all the products in the market. Therefore, it is important to develop and maintain an easy-to-use tool, from which consumers can fast and easily check the most relevant safety features they ought to look for in a product, to determine the safety/compliance of said product. In addition, the products of today are increasingly complex and can cause serious risks if used in a wrong manner or environment. Thus, it is important that consumers have easily accessible information on the most relevant aspects of the safe use of their products.

The objective of this research is to develop a proof of concept version of an easy-to-use product safety check tool for consumers to be used in their mobile devices. The tool was decided to be used with mobile devices because in 2015 almost 90 % of Finns between

16 - 89 years old used an internet and almost 70 % used a smart phone (stat.fi, 2015). The amount of smart phone and tablet users can be expected to increase in the future as younger generations use these devices lot more than older generations (stat.fi, 2015).

The example context for the proof of concept version of the easy-to-use product safety check tool that will be created as a part of this applied research project was chosen to be two different products: candles and cigarette lighters. Other types of products will be subsequently added to the tool using same principles as used for the example product groups.

This project aims to give consumers an easy way of checking most relevant safety information with just a few clicks of their mobile device, where ever they are.

In addition to getting the relevant safety information of a specific product, consumers' general knowledge about product safety will increase while using the tool. The tool will also help Tukes' market surveillance activities by getting more accurate notifications about possibly dangerous products, as the tool will include the possibility for consumers to send notifications to Tukes.

1.5 Thesis Outline

This thesis comprises 4 phases. In Phase 1, I will do a literature review of two subjects relevant to this project;

1. Software application usability aspects
2. Factors impacting consumer education/safety information effectiveness

In Phase 2, I will conduct a quantitative study of current consumer behavior regarding product safety. The study will be done as a quantitative questionnaire and the sample will represent adult mainland Finnish population. In this phase I will also gather secondary data from laws, regulations and standards, from which the safety education information will be developed.

In Phase 3, a proof of concept version of an easy-to-use product safety check tool will be created, based on the knowledge obtained in Phases 1 and 2.

In Phase 4, once the proof of concept version is created, a qualitative focus group study is conducted to determine the functionality of the tool.

2 Method and Material

2.1 Research Plan

The research plan as a chart from the Objective to Outcome is illustrated in Figure 1. This research will consist of a literature review of subjects relating to mobile software application usability aspects and safety education effectiveness factors, which will construct the conceptual framework. After the literature review, I will analyse the current state of consumer behavior regarding product safety. The analysis will be conducted as a quantitative questionnaire study. In addition to the consumer behavior, I will also examine laws, regulations and standards eliciting the relevant safety components and requirements of the two product groups, which are chosen to be the example context products in the development of the proof-of-concept version of the easy-to-use product safety check tool that will be created in this research project.

From there on I will, using the knowledge gathered in the previous phases, create a proof-of-concept version of the easy-to-use product safety check tool and the safety education information to be utilised in the tool. In the final stage, a small-scale user validation test is conducted in order to get feedback on the functionality and usability of the proposed design.

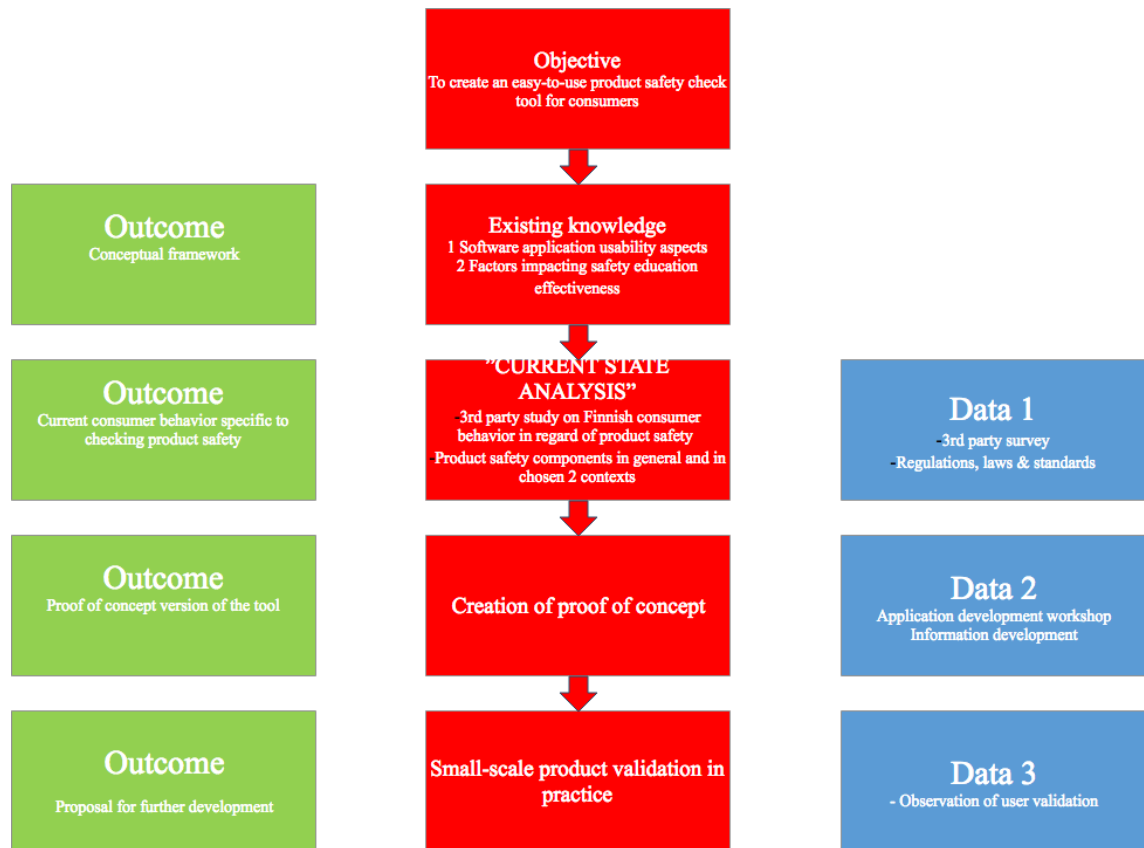


Figure 1, The research plan as a chart

2.2 Data Collection and Analysis

The data collected and created in this research is divided in to three different types. The first data sets to be gathered are data concerning current consumer behavior regarding product safety and the product safety components elicited in laws, regulations and standards. Second data set is a data that will be created during this research and it will consist of safety information education data and mobile application design data. The third data set to be collected is a focus group feedback data, which is collected to validate the created proof-of-concept version and to gather comments for further development.

The data 1a, current consumer behavior and knowledge about product safety, is collected by conducting a quantitative survey. The survey will have 1012 respondents, who are selected to represent the Finnish adult population. The results of the survey have a margin of error of approximately 3 percentage points at the 95 percent confidence level. The questionnaire will consist of 27 product safety related questions, which are designed by me in cooperation with the representative of the company conducting the survey,

Kantar TNS. The data collection and analysing methods are further explained in section 4.

The data 1b, product safety components elicited in laws, regulations and standards, is collected by conducting a thorough review of all laws, regulations and standard concerning the two product groups that are chosen to be the example context in the proof-of-concept. The data collection and analysing methods are further explained in section 4.

The data 2a and 2b will be developed within this research. The developed data is the product safety education information created to be utilised in the proof-of-concept version, and the design of the actual mobile application, that will also be created. The data collection and analysing methods are further explained in section 5.

The data 3, focus group feedback, is collected from in a qualitative manner from an open discussion session with the focus group after a product try-out period. The discussion will be conducted using the Single Focus Group method. The Single Focus Group discussion session will last 30 minutes. The participants of the focus group consist of 7 subjects, who are market surveillance experts from the consumer product unit of the Safety and Chemicals agency (Tukes). The discussion is recorded and analysed using the framework analysis method. The data collection and analysing methods are further explained in section 6.

The data collection plan is shown in *Table 1*.

Data collection point	Data source	Content of data collection	Outcome of data collection	Participants	Date & Duration
Current state analysis					
Data 1a	Questionnaire	Obtaining knowledge on current consumer behavior and knowledge	Current consumer behavior and knowledge level	1012 Respondents	Data gathering period 5-7.5/17
Data 1b* *Secondary data	Literature review	Overview of regulations, laws & standards	Current regulations, laws & standards	Jyri	1-3/17 and 6-8/18
Creation of demo version of the tool					
Data 2a	Development	Creation of information for the tool	Information for the tool	Jyri	1-2/17 and 7-8/18
Data 2b	Development	Creation of a proof of concept version of the tool	Proof of concept version of the tool	Jyri + outsourced coder	2-3/17 and 8/18
Validation tests					
Data 3	Focus group interview	Product safety experts' view of tool and information functionality	Proposals for further development	7 Participants	Try-out period 17-19.9.2018 (3 days) Discussion session 20.9.2018 (30 min)

Table 1, Data collection plan

3 Literature

In order to create a functioning software application with pleasant usability, one needs to determine the key aspects influencing the usability experience of such application. In this section I will elicit the existing knowledge concerning these aspects. Furthermore, as the application created in this project is aimed at informing and educating consumers about consumer product safety, I will elicit the existing knowledge on the key aspects influencing the information and education effectiveness.

Initially I was going to elicit the existing knowledge directly related to consumer behavior in regard of checking product safety prior to purchase decision, but to my great amazement, I couldn't find any articles about the subject. Due to this fact, I derive the effectiveness factors from literature of two different fields; information effectiveness and safety education effectiveness.

3.1 Aspects influencing software application usability

There are several functional and design aspects influencing the usability and user experience of a mobile software application. In a study conducted by Hoehle et al. (2016) to conceptualize and develop scales for mobile application usability they identified ten different constructs that affect the usability of a mobile application. These are: Aesthetic graphics, Color, Control obviousness, Entry point, Fingertip-size controls, Font, Gestalt, Hierarchy, Subtle animation, and transition.

In addition to the constructs identified by Hoehle et al. (2016), two features, not directly related to the development of the application that play an important role in user experience, can be derived from a global survey done by Compuware (2012). These features are the (application) Loading time and (application) Reliability.

3.1.1 Aesthetic graphics

Aesthetic graphics is probably one of the first things where users can be impressed and drawn to use a mobile application. While there isn't a widely accepted mutual understanding on what constitutes a good aesthetic graphics, there are some guidelines. For example, Hoehle and Venkatesh (2015) propose using rich, beautiful and engaging graphics, beautiful high-resolution artwork and replicating the look of high-quality/precious materials. They also suggest creating high quality launch images and application icons.

3.1.2 Color

Color and color schemes used in an application has a big impact on how appealing users rate the application. Studies have shown that the users react more favorably to highly colorful mobile application interfaces (Sonderegger et al, 2012). One explanation (Sonderegger et al (2012) suggest for the better usability of applications having highly colorful color schemes is the contrast it creates. Having a highly colorful application affects positively on the readability of the display, as the contrast between the controls and information in the application and the background is higher.

3.1.3 Control obviousness

For an application to be viewed as having good usability, it is important that the controls in the application are immediately obvious for users. This is suggested for example in a usability checklist for the usability evaluation of mobile phone user interface created by Ji et.al (2006). Huang et al (2006) also suggests that the control functionalities in mobile application should be immediately obvious to the user since they are displayed in a small screen. Hoehle and Venkatesh (2015) further emphasizes the same issue, stating that the mobile application controls should make the functions of the controls immediately apparent. They suggest it could be done, among other things, by:

- minimizing the number of controls
- clearly labeling the controls
- being consistent with the usage paradigms.

3.1.4 Entry point

The importance of entry points is evident in websites and similar content points that are mostly accessed by internet browsers with computers. The entry point concept is, however, different with mobile device applications. While it is understood that in for example websites content should be accessible via several alternative entry points. i.e. links on the site, for mobile applications it appears to be also important on how a consumer finds the application itself in their mobile device. Benbunan-Fich and Benbunan (2007) found

that some users are unable to find the application in their mobile devices after downloading it, and that it will cause frustration among those users. This knowledge extends the entry point concept from the accessing the content to accessing the application. As the placing of the shortcut to the application after downloading is predetermined by the mobile device's user interface, the only aspect which can be manipulated to enable the user to more easily find the application in their mobile device is the shortcut icon.

3.1.5 Fingertip-size controls

The size of the control buttons effects the usability of the application, especially with older users. The controls should not be too small. Users find it easier to select functions in the application if the control buttons are relatively large (Kurniawan, 2008). However, too large buttons aren't suitable for mobile devices either due to limited screen size (Brewster, 2002). Hoehle and Venkatesh (2015) argues that the fingertip size control should be about 44×44 points. Brewster (2002) have also discovered that by including a sound to the button (control) will further increase the usability of the application. This is generally diverted to vibration in modern mobile applications however.

3.1.6 Font

Font is a major aspect in text readability, and thus application usability. The font size is suggested by Kim et al. (2005) to have a critical impact on the usability of a mobile application, as it effects the information showing efficiency and information readability. Furthermore, Bernard et al. (2003) found that users prefer 12-point dot-matrix Arial over 12-point dot-matrix Times (new roman) and 12-point anti-aliased Arial text, suggesting dot-matrix being perceived as more favorable than anti-aliased, and Arial over Times. The same study also discovered that 12-point font size was overwhelmingly favored over 10-point font size. The dot-matrix type font is, however no longer in use as the rapid development of screen technology has deemed it unnecessary.

3.1.7 Gestalt

The gestalt theory is a set of gestalt laws explaining how humans observe and make perceptions about different objects in their environment (Wertheimer and Riezler, 1944). Möller et al. (2012) define the gestalt principles as "a structure, configuration or layout that is unified and has specific properties that are greater than the simple sum of its individual parts". The impact of applying gestalt principles to mobile applications has been studied by Paay and Kjeldskov (2007) who found that applying the principles to a location based mobile service helped understanding how the users perceive the application functionality. They managed to identify five gestalt laws that were relevant to mobile application; namely proximity, closure, symmetry, continuity, and similarity.

3.1.8 Hierarchy

The hierarchy of the content and functions within the application is an important concept for a mobile application. The hierarchy helps the user to understand the inherent navigational logic within the application. Using titles and subtitles to indicate the hierarchical structure makes it easy for the user to navigate within the application (Adipat et al., 2011). Also, Hoehle and Venkatesh (2015) suggests that the application should be structured so that the interface structure is easy for the user to perceive.

3.1.9 Subtle animation

Subtle animation in mobile applications has a very important role in informing the user that the desired operation has been recorded and the function is launching, for example by changing the color of the control after a push has been recorded. Another important function for subtle animation is in making the application more pleasant during loadings, by providing a nice animation during loading.

Hoehle and Venkatesh (2015) suggest that by using subtle animation one can communicate effectively to the user, but the animation should not get in the way of user's tasks or slow down the application. They propose using subtle animation to communicate status and enhance the sense of manipulation and help users visualize the results of their

actions (Hoehle and Venkatesh, 2015). The animations and graphics used, however, should not be too rich and complex, as it might impair the level of communication to the user by distracting the user (Mayer, 2001).

3.1.10 Transition

Transitioning from page to page within a mobile application should be designed to be easy for the user and the application should assist the user (Adipat et al., 2011). Smooth transitioning from page to page is a big part of the application efficiency as it reduces the time to navigate within the application (Nilsen, 2000). Lee et al (2009) emphasizes the smooth transitioning in mobile applications as it improves users' perception of the application quality.

3.1.11 Loading time

The application loading time is also an important usability factor for consumers, especially in mobile devices. According to global survey conducted by Compuware (2012, p 11) 80 percent of mobile application users expect an application to launch in three seconds or less. While the loading time is important to consumers also in websites, the factor is emphasized in mobile applications. Most consumers expect a mobile application to launch faster or at least as fast as websites (Compuware, 2012, p 11). Therefore, features requiring a large amount of data to be loaded, such as automatically opening videos and large images, should be avoided as far as possible.

3.1.12 Reliability

We have come far from the days when consumers were willing to spend time and energy to get an electronic device or videogame to work. While in the 90's blowing several times to a Nintendo game cassette to get it launching was almost considered as a feature, and nobody complained, let alone stopped using the device, in today's world only 16 percent would give an application a new try, if it failed to launch in the first 2 attempts (Compuware, 2012, p 10). It is therefore essential for an application to launch and work reliably, without crashing every once in a while.

3.2 Implementation of the aspects influencing software application usability

The aspects described in the previous section are largely used as best practises in current user interface design. These have been integrated in many user interface guidelines from several software vendors. In this work these best practises are implemented by following the design guidelines of the Google Material Design (Material Design, n.d.). This also makes the application interface familiar to menu mobile application users, as these guidelines are used by the Android operating system and many applications developed for it.

3.3 Aspects influencing information effectiveness

From the literature review two aspects influencing the effectiveness of safety information emerged. These were the amount of the information given and the type of the information given. These two aspects are further studied and explained in this chapter.

3.3.1 Amount of information

In safety education context the amount of information provided to a consumer plays a significant role. The more times an individual sees certain warnings or educational material, the more impact the material has on the individual's behavior. For example, while studying the effectiveness of safety education to children's playground behaviour, Reid and Preusser (1983) found that providing a little bit of education material (1/2 material sets) had no statistically significant effect on the children's behavior, but when they provided more educational material (2/2 sets) they found a statistically significant positive change in the children's playground behavior. Moreover, the positive change in the behavior persisted over time, indicating that effective education has long lasting positive effects also after the education period (Reid and Preusser, 1983)

3.3.2 Type of information

People react in different ways to different types of information. It is important to provide such information to the users of the application that will have the desired effect on the users' behavior, and that will promote continual use of the application. It is therefore of

utmost importance to determine whether the information should be of the “warning” type or the “educational” type, of a mixture of both. While it is suggested that providing educational information in sufficient context might have a positive impact on the person’s behavior with the product/service (Reid and Preusser, 1983), it’s not clear if the behavioral change will cross over to purchase behavior and purchase decisions. However, studies have shown that if a product is not seen as dangerous, the consumers are less likely to notice warnings within the product and further they are also more prone to not read and comply with the warnings (Wogalter et al. 1991). This type of behavior has also been found to happen in studies looking into the issue from the opposite direction. Numerous studies suggest that the more hazardous a product is seen by the consumer, the more effect a warning within the product has (Frantz, 1994, Friedmann, 1988, Godfrey et al, 1983). It would therefore make sense to incorporate both “warning” type and “educational” type information to the application. This way consumers’ knowledge of the potential dangers the product poses would increase, and the warnings would then have greater effect on the consumer as well.

There aren’t any studies made about which types of products Finnish consumers should be educated about, or about which types of products Finnish consumers feel they need more safety education. Therefore, these variables were studied by a quantitative questionnaire in this research project. The results are expressed in section 4 of this thesis.

3.4 Aspects influencing safety education effectiveness

The effectiveness of different aspects of safety education to reducing accidents related to consumer products have been studied mostly in United states of America in the 1970’s. The interest for studying the field arose from the establishment of the Consumer Product Safety Commission (CPSC) in 1972. The CPSC was established with passage of the Consumer Product Safety Act.

Based on the studies from the era, two aspects of the education material seem to play an important role on the effectiveness of the education programs: the amount of education material and the type of education material. These two aspects are further studied and explained in this section.

3.4.1 The amount of education material

In a study conducted by Staelin (1977) to examine the relationship between consumer's knowledge about how they should behave (normative behavior) and how safely they used the products (actual behavior), he found that risen normative behavior had little to no relation to the actual behavior. This may result from various reasons, but one hypothesis that shouldn't be overlooked is the change in risk taking behavior. Consumers may feel that as they know how they should behave, they are aware of the risks associated with the act, and they are more willing to take the (known) risk. The outcome of the study may however result from the research design. In his study, Staelin had eight 30-minute education modules held to students by engineers, emphasizing the technical principles of how one could assess the safety of a consumer product. The education modules did increase the normative behavior by a statistically significant amount, but the behavior did not extend to actual behavior. Based on Staelin's research, Reid and Preusser (1983) conducted similar research about the effectiveness of a child playground safety education program by CPSC. The results of this research suggest a different outcome. The study suggests that safety education programs could have a statistically significant positive impact on actual behavior, if conducted properly. They also found that limited safety education material distribution had minimal impact.

3.4.2 The type of education material

The type of effective educational material regarding modifying consumer behavior seems to follow the same pattern as the warning information effectiveness. Studies indicate (Staelin, 1977 vs. Reid and Preusser, 1983) that simply educating consumers of different aspects of consumer products/services, without explaining how and why to behave more safely, does not seem to have the desired effect. Educating a proper way of using a product safely might actually have an adverse effect to the behavior as it might encourage consumer to take more "known" risks (Staelin, 1977). Using more strategic education material wherein the explaining the desired behavior and highlighting the dangers posed by the products are combined, seems to work better in altering the consumer behavior.

3.5 Conceptual Framework

The conceptual framework of this research comprises different aspects and elements that affect usability and functionality of mobile applications, and the impact of safety education in altering consumer behavior. The conceptualization was done primary for the efficient communication of the safety information. The developed application also includes additional features, which are not directly related to communication of product safety information. As discussed previously, these aspects can be divided in four different elements: Information, Education, (application) Functional design and (application) Visual design. These elements can be further divided into more specific aspects of the element. These four elements then create the foundation for high information effectiveness and (application) usability. By incorporating all the elements in a right manner to the mobile application, the result should be a properly functioning product safety check tool that will positively alter the consumer behavior regarding product safety related issues. The conceptual framework is presented in Figure 2 as a flowchart.

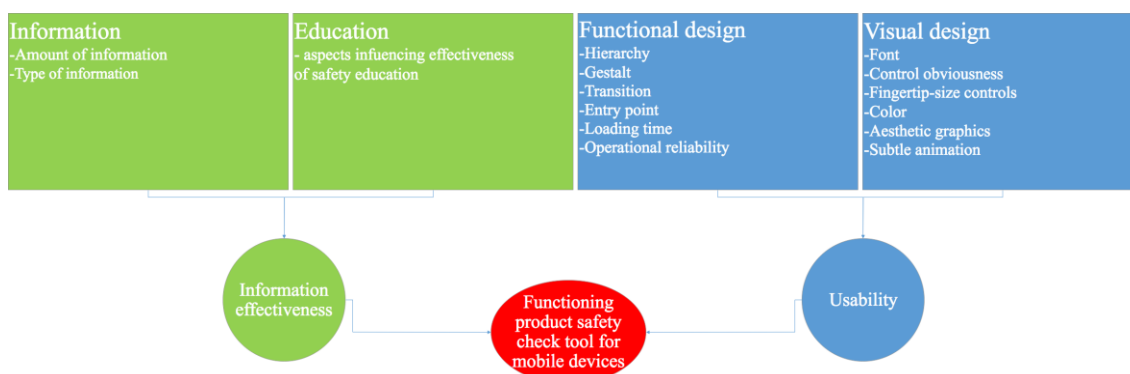


Figure 2, Conceptual framework as a flowchart

4 Current state analysis

4.1 Current state of consumer behavior regarding product safety

The current consumer behavior regarding product safety was studied by conducting a quantitative questionnaire study with a sample representing adult mainland Finnish population with three percent margin of error at 95 % confidence level in most questions (1012 respondents). This margin of error was achieved by selecting the respondents by

using Kantar TNS's respondent weighing model. The model uses for example the respondents' location, gender, age, stage of life, employment status, education level, gross income, economic status etc., to distribute the respondents to cover the whole Finnish population as far as possible. The questions for the questionnaire were designed jointly by me and a Kantar TNS representative. The questions were developed based on general consumer behavior patterns recognized in the literature review, and by using Tukes' implicit knowledge about consumer behavior. The questions were subjected to several iterations within Tukes and in my circles (including several academics) before they were deemed to be valid. The questionnaire study including the preliminary analysis of the results was conducted by Kantar TNS, the leading market research company in Finland. The questionnaire consisted of 27 different product safety, consumer knowledge and consumer behavior related questions. The questionnaire was commissioned in Finnish, due to the Finnish speaking respondents. The questions loosely translated to English were as follows:

- How well do you feel you know matters related to product safety?
- How many products (product titles, not individual products) Tukes removes as dangerous/non-compliant from the market annually?
- How many recall notifications you remember seeing within the last year?
- (Thousands of new consumer products are introduced to Finnish market every year, such as toys, tools, furniture etc.). Do authorities make pre-market inspections for those products?
- Have you heard about Tukes' market surveillance register Marek?
- Have you heard about European register of dangerous products Rapex?
- Have you heard about OECD's register of dangerous products Global Recalls?
- When you are acquiring a new product, do you make sure the product is safe prior to purchase decision?
- Where do you search for product safety related information?
- What types of products' safety do you try to be sure of prior to purchase decision?
- How do you ensure, that you use a product safety that is new for you?
- What type of products' safety features or safe use you would want more information?
- In what situations/places you feel you would need easily accessible safety features or safe use related information?

- What type of information you feel you need when assessing the safety of a product?
- Have you ever tried to find safety information about a product, but were unable to find it?
- Do you think you would check product safety related information more, if it were more easily available?
- When you purchase a product, do you read the manual?
- What you look at in the manual?
- What types of products' manual do you read?
- How likely would you use a internet based service, from where you would get a notification if authorities deem the product you already purchased, dangerous or non-compliant?
- How would you like to receive the notification about dangerous or non-compliant product?
- Do you check the product safety labels when you purchase a product?
- Do you understand what the product safety labels mean?
- Do you know the meaning of the following product safety labels?



- Do you feel you would need more information about the meaning of product safety labels?
- What CE-mark in a product means for you?
- How you would likely act, if you found a product you have purchased to be dangerous or non-compliant?

All the questions with the answer distribution as percentages from all respondents are shown in *Table 2* below (loosely translated from Finnish to English):




Total	Base	1012
	Total	100,00
How well do you feel you know matters related to product safety?	Very well	2,92
	Fairly well	32,56
	Not well nor poorly	42,63

	Fairly poorly	14,09
	Very poorly	4,01
	Can't say	3,79
How many products (product titles, not individual products) Tukes removes as dangerous/non-compliant from the market annually?	About 10 Pcs	12,55
	About 250 Pcs	57,58
	About 1000 Pcs	24,24
	About 5000 Pcs	5,63
How many recall notifications you remember seeing within the last year?	None	14,69
	1-5	45,15
	6-10	17,18
	11-20	12,76
	21-50	6,14
	Over 50	4,08
How many recall notifications you remember seeing within the last year?	Mean	11,7
	Min	0
	Max	100
	stddev	20,33
(Thousands of new consumer products are introduced to Finnish market every year, such as toys, tools, furniture etc.). Do authorities make pre-market inspections for those products?	Yes, for all product categories	31,08
	Yes, for some product categories	55,56
	Don't do at all	4,42
	Can't say	8,94
Have you heard about Tukes' market surveillance register Marek?	Yes	10,09
	No	81,61
	Can't say	8,30
Have you heard about European register of dangerous products Rapex?	Yes	12,45
	No	81,85
	Can't say	5,70

Have you heard about OECD's register of dangerous products Global Recalls?	Yes	10,09
	No	84,28
	Can't say	5,63
When you are acquiring a new product, do you make sure the product is safe prior to purchase decision?	Yes, I make sure a product is safe before purchase decision	7,09
	Yes, I make sure a product is safe while purchasing it	23,52
	No, I trust only safe products are sold	57,62
	No, I don't think about product safety	6,19
	Can't say	5,58
Where do you search for product safety related information?	From the internet	58,14
	From literature	3,59
	From the seller	48,10
	From elsewhere, where?	2,51
	Nowhere	15,43
	Can't say	6,10
What types of products' safety do you try to be sure of prior to purchase decision?	Toys	46,26
	Protective equipment	53,52
	Domestic appliances	75,36
	Hobby- and sporting equipment	36,75
	Power tools	74,24
	Gas appliances	48,54
	Childcare articles	28,85
	Decorative articles	16,34
	Something else, What?	1,97
	Nothing	2,73
How do you ensure, that you use a product safety that is new for you?	I read the user manual or product data sheet with care and use the product accordingly	71,99
	I find the guidance for safe use of the product from elsewhere (e.g. internet)	18,12
	I find the safe use guidance of the product from the seller	21,51

	I trust in knowing how to use the product safely	21,90
	Something else, what?	0,86
	Can't say	4,86
What type of products' safety features or safe use you would want more information?	Toys	15,73
	Protective equipment	21,91
	Domestic appliances	42,90
	Hobby- and sporting equipment	15,05
	Powertools	39,73
	Gas appliances	33,19
	Childcare articles	10,40
	Decorative articles	10,05
	Something else, what?	1,30
	Nothing	30,54
In what situations/places you feel you would need easily accessible safety features or safe use related information?	At a store	47,65
	At home	44,59
	At work, school or place of education	14,89
	At summer cottage or vacation	13,85
	Some other situation, what?	0,92
	Can't say	17,19
What type of information you feel you need when assessing the safety of a product?	Technical requirements set for the products	39,67
	Information about the meaning of product safety markings	27,85
	Information about safe use	63,25
	Information about the suitable user group for the product	22,58
	Something else, what?	1,03
	I don't feel the need for any information	10,18
Have you ever tried to find safety information about a product, but were unable to find it?	Yes	15,21
	No	54,66
	Can't say	30,13
	Yes	49,26

Do you think you would check product safety related information more, if it were more easily available?	No	22,24
	Can't say	28,50
When you purchase a product, do you read the manual?	Always	22,67
	Almost always	47,48
	Every now and again	16,30
	Randomly	9,84
	Never	2,40
	Can't say	1,31
What you look at in the manual?	The assembly / installation / commissioning guidance	88,43
	The mechanical / physical / chemical properties related to product safety	43,01
	The guidance for safe use	59,23
	Something else, what?	1,00
	Can't say	2,77
What types of products' manual do you read?	Toys	14,88
	Protective equipment	33,88
	Domestic appliances	82,06
	Hobby- and sporting equipment	29,62
	Powertools	67,20
	Gas appliances	43,84
	Childcare articles	10,96
	Decorative articles	14,16
	Something else, what?	1,49
	Can't say	4,95
How likely would you use an internet-based service, from where you would get a notification if au-	I would certainly use	17,18
	I would likely use	35,72
	I would maybe use, consider using	26,79
	I wouldn't use	10,47
	Can't say	9,84

thorities deem the product you already purchased, dangerous or non-compliant?	Mean	2,66
How would you like to receive the notification about dangerous or non-compliant product?	SMS message	25,20
	E-mail	52,70
	"Push notification" (notification coming to a smartphone)	13,27
	Something else, what?	1,44
	Can't say	7,39
Do you check the product safety labels when you purchase a product?	Always	9,90
	Almost always	33,88
	Every now and again	24,35
	Randomly	18,33
	Never	8,87
	Can't say	4,67
Do you understand what the product safety labels mean? 	I understand the meaning of all or almost all	6,06
	I understand the meaning of several	31,89
	I understand the meaning of some	39,89
	I hardly understand the meanings	13,59
	I don't understand the meanings	2,48
	Can't say	6,09
Do you know the meaning of this product safety label? 	Yes	85,28
	No	10,38
	Can't say	4,34
Do you know the meaning of this product safety label? 	Yes	90,57
	No	6,88
	Can't say	2,55


Do you know the meaning of this product safety label? 	Yes	66,29
	No	24,92
	Can't say	8,79
Do you know the meaning of this product safety label?	Yes	52,85
	No	38,25
	Can't say	8,90
Do you feel you would need more information about the meaning of product safety labels?	Yes, substantially more	13,35
	Yes, little bit more	51,72
	I don't feel the need more information	28,12
	Can't say	6,81
What CE-mark in a product means for you?	The product is of high quality	2,10
	The product is safe	20,47
	Manufacturer assures that the product fulfill the requirements imposed on it	64,74
	I don't know what CE-mark is	12,69
How you would likely act, if you found a product you have purchased to be dangerous or non-compliant?	I contact the seller	82,04
	I contact the importer	23,40
	I notify authorities	14,14
	I write a critical review to social media	4,62
	I dispose of the product	10,54
	Continue using the product normally	1,76
	Something else, what?	0,60
	Can't say	6,19

Table 2, questionnaire data

4.2 Key findings of consumer behavior regarding product safety

The key findings from the questionnaire study, conducted to get up to date knowledge of current consumer behavior regarding consumer product safety related issues, relates to consumers' (mis)conceptions about market surveillance activities and behavior

once the consumers find a product to be dangerous and/or non-compliant. Furthermore, the study revealed insight into consumers' product safety education needs.

4.2.1 Knowledge and behaviour regarding market surveillance

31 percent of the respondents thought that authorities conduct pre-market inspection to all product groups and further 56 percent thought that pre-market inspections are conducted to some product groups. Hence in total 87 percent of consumers think that pre-market inspections are conducted to at least some consumer product groups, while in reality no pre-market inspections are conducted for any consumer product groups. Only 4 percent of the respondents answered correctly to the question. This is highly alarming to market surveillance agencies, as it may lead to consumer not questioning the safety and compliance of products they are purchasing or using. The finding clearly indicates a need for authorities to reiterate the methods and volumes of consumer education.

The answers to question "When you are acquiring a new product, do you make sure the product is safe prior to purchase decision?" yielded similar responses. 31 percent told that they ensure the safety of the product either prior to purchasing or while purchasing. Alarmingly, 64 percent told that they do not ensure the product safety prior to purchasing, this includes the 56 percent who answered that they do not ensure the product safety as they "trust that only safe products are in the market". This distribution makes sense, however, as also a high percentage of the respondents believed that authorities conduct pre-market inspection for all or some consumer product groups.

Another interesting fact arose about consumer behavior when they encounter a dangerous/non-compliant product. Only 14 percent told that they would make a notification to authorities, while 82 percent told that they would contact the seller of the product. While it is mandatory by law for economic operators to inform authorities when they learn that their product poses a threat to consumers (kuluttajaturvallisuuslaki 920/2011, 8 §), these numbers indicate that most economic operators fail to do so. Based on this finding, it can be assumed that the information about dangerous/non-compliant product found in the market by consumers never reaches authorities. The reasoning of this consumer behavior is unknown, but it might relate to lack of knowledge about market surveillance agencies, i.e. the possibility to make such notifications to authorities.

When asked if the respondents had heard about different market surveillance registers, websites where dangerous/non-compliant products are listed by authorities, only 10 percent had heard of Tukes' register Marek, 12 percent had heard about the EU's register Rapex, and 10 percent about the OECD's register Global Recalls. Based on the similar percentages of knowledge of the three registers, it is highly likely that it was the same 10-12 percent group that had heard of all of them. This is another issue authorities should tackle by increased education toward consumers, as these registers are the sole place for consumers to get up-to-date information about products deemed dangerous/non-compliant by authorities.

The product recall notifications do not seem to reach consumers very effectively. Tukes imposes economic operators to make product recalls to about 100 products per year (marek.tukes.fi, 2018), but in contrast the mean number of recall notifications consumers reported seeing was only 11,7.

4.2.2 Consumers' knowledge of warning symbols

The use of warning symbols or texts plays a significant role in product regulation. There are a lot of product types in the market that pose an inherent risk which can't be eliminated by product design or safety features. For these types of products, the regulator demands relevant warning symbols or texts to be placed on the product or product packaging to ensure the consumers use the product in the designed manner and are aware of the risks related to the use of the product. Many economic operators decide to use the warning symbols instead of text for variety of reasons. For example, it may be difficult to incorporate all the relevant warning texts to small products, or some economic operators feel the symbols align better with their product/package design.

It is however not clear if consumers understand the meaning of all the symbols, which is critical to achieve the wanted outcome. I studied this matter by asking generally about the (believed) knowledge level about the symbols, and by asking if the respondents knew the meaning of four different symbols. 76 percent of the respondents said they know the meaning of some or all of the symbols. Only 6 percent claimed knowing them all. On the positive side, only 2 percent said that they don't know the meaning of any symbols. When asked about knowledge of the meaning of the four specific symbols, it became clear that

the symbols that are widely used were known best, and more product specific symbols less so. While 91 percent claimed knowing the meaning of the symbol “not suitable for children under 3 years”, and 85 percent the “never expose to heat above 50 degrees C or to prolonged sunlight”, only 66 percent answered knowing the meaning of “explosive” and mere 53 percent knew the meaning of symbol depicting “do not leave burning candle unattended”.

The responses to the previous questions seem to correlate with consumers’ own conception about the need for further education about the meanings of warning symbols, as only 28 percent felt that they wouldn’t need further education of the matter, while 52 percent felt the need for some further education and 13 percent for significantly more education.

4.2.3 Consumers’ need for education and information

The need for more easily available and compiled consumer product related safety information became quite clear based on what consumers felt they need. Almost half of the respondents (49 percent) believed that they would check product safety related information more if it was more easily available. The information should also be accessible in mobile environments as 48 percent of the consumers felt that they would need access to the information in stores, 15 percent in work/school, 14 percent in summer cottage or on holiday. While 45 percent said they would need access to the information at home, it is highly likely that a large portion of those consumers would use a mobile device to search the information at home as well.

Out of the given possibilities most of the consumers felt they would need more information about the safety features / safe use of domestic appliances (43 percent), power tools (40 percent) and gas appliances (33 percent). Oddly consumers didn’t seem to need more information about toys (16 percent) or childcare articles (10 percent), even though these are among the top priorities in Tukes’ market surveillance. This indicates that consumers want more information about the product groups they deem dangerous, and toys and childcare articles doesn’t fall into that category.

Out of the given options, the respondents overwhelmingly said they needed information about safe use and technical requirements set for the products, 63 and 40 percent respectively, while only 28 percent wanted information about the meaning of product

safety markings and 23 percent about the suitable user group for the product. These answers go hand in hand with the responses to questions about usage of user manuals. Out of the respondents who replied they read the user manual, 88 percent said they read the assembly / installation / commissioning guidance, 59 percent the guidance for safe use and 43 percent the mechanical / physical / chemical properties related to product safety.

Lastly, it was highly motivating to find out that most consumers would use an application, from which they would receive notifications from authorities if a product they had already purchased was found to be dangerous or non-compliant. 17 percent said they would certainly use the application, 36 percent, would likely do so and 27 percent would consider using it. Only 10 percent said that they wouldn't use such an application. This knowledge shows that my initial hunch seems to have been correct, and thus it is important to develop this type of product safety check application for consumers.

4.3 Product safety components in general

The information to be shown in the application's product safety information sheets was developed by examining how the market surveillance expert, responsible of the market surveillance activities for the given product type, would examine the safety and compliance of said product. In the market surveillance activities, the experts partly rely on past experiences and profound knowledge of different features of the product, but the main source of product type related compliance information comes from relevant standards. As it is not possible to write down the implicit knowledge the experts poses', the information in the application will be mostly based on the features that could be retrieved from relevant standards.

4.4 Product safety components in two example contexts

The example context of the safety information sites was chosen to be those of Candles and Cigarette lighters. Both products are considered as general consumer products and thus they fall under the scope of General Consumer Product Directive 2001/95/EC (GPSD). GPSD aims to ensure that only safe products are made available on the European market. GPSD as such doesn't impose any specific safety requirements, but more generally states that no consumer product shall pose danger to consumers. The GPSD

is implemented in Finnish legislation with the Consumer Safety Act (Kuluttajaturvallisuuslaki 920/2011).

The GPSD is a product directive which applies when there are no other product related EU legislation or other type of codes of practises relating to the specific products' safety requirements (European Commission, 2018).

The safety of candles and cigarette lighters in Finland are enforced with the Consumer Safety Act which states that “any consumer good that can, because of a flaw or imperfection in its structure or composition or because of any false, misleading or inadequate information supplied in respect of said consumer good, or because of its misleading appearance, cause injury, poisoning or illness or pose some other danger to health”, shall be considered hazardous to health (and therefore not compliant to be placed on the market) (Kuluttajaturvallisuuslaki 920/2011).

As the GPSD and Consumer Safety Act only provide a legislative framework for the market surveillance purposes, the actual specific safety requirements for products falling under the scope of GPSD and Consumer Safety Act are often defined in EU-standards (EN). In the case of absence of an EU-standards the requirements may be defined in either national (SFS) or in some cases in international (ISO) standards. Should there be no specific standard, the minimum safety level for such a product would be set by the relevant economic operator, and in case of market surveillance activities the relevant market surveillance authority, based on GPDS and Consumer Safety Act.

In addition to the product specific safety information, all product sites in the application will include information if the product should bear a CE-mark or not. This information is an important aspect for the consumer and for the market surveillance agencies, as by CE-marking a product, the relevant economic operators signify that the product sold has been assessed to meet the relevant European requirements, including the safety and health requirements. However, not all products placed on the European market shall bear a CE-marking. The marking is compulsory only for certain products which are covered by so called New Approach Directives. For all other products it is forbidden to affix CE marking. Therefore, consumers should pay attention, and avoid acquiring products, that should be CE-marked, but are not, and products that shouldn't be CE-marked but are, as it indicates that the economic operator is not up to date about its responsibilities,

and the product might not be safe. As it is not possible for an average consumer to know if a specific product should bear a CE-mark or not, the information in the application will be of great help.

4.4.1 Candles

The specific behavioral and constructional safety features required from candles are set in three relevant European standards: SFS-EN 15426 - Candles. Specification for sooting behavior, SFS-EN 15493 - Candles. Specification for fire safety and SFS-EN 15494:2007 Candles - Product safety labels. Even though these standards are not so called Harmonized European standards, meaning that the reference numbers of them haven't been published in the European Union official Journal, they do de-facto set the minimum safety requirements.

4.4.1.1 SFS-EN 15426 - Candles. Specification for sooting behavior

This standard sets the maximum limit of soot produced by a candle. The limit is based on an average hourly soot production of three identical candles. The maximum allowed soot per candle on average amounts to index number 1.

4.4.1.2 SFS-EN 15494:2007 Candles - Product safety labels

The product safety labels consist of four mandatory and 11 voluntary labels in addition to a general warning symbol. The Information can be given either in text or by using the pictograms depicting each warning, given in the standard. The four mandatory labels are:

- Never leave a candle burning unattended.
- Burn candles out of the reach of children and pets.
- Always leave at least XX cm between burning candles. (XX represents the minimum safety distance as recommended by the manufacturer.)
- Do not burn candles on or nearby anything that can catch fire.

The voluntary labels are:

- Do not place candles in a draught.
- Do not place candles near a source of heat.
- Place candles in an upright position.
- Trim wick to about 1 cm before lighting.
- Always snuff out the flame. Do not blow it out.
- Always use a candleholder.
- Keep the wax pool clear of matches and other debris to avoid flaring.
- Only use tea lights in holders and warming stoves with sufficient ventilation.
- Do not move a burning candle.
- Use a suitable glass or holder as these candles liquefy when burning.
- Never use liquid to extinguish.

4.4.1.3 15493 - Candles. Specification for fire safety

The standard deals with the constructional and behavioral aspects of candles. According to the standard a candle should have flame height not higher than 30 mm for tealight candles or not more than 70 mm for other types of candles. Candles used without candleholder (pillar / table candles) shall not tip over when they are placed on a 10° tilted plane. There shall be no secondary ignitions lasting more than 10 seconds, meaning nothing else than the wick shall not ignite.

4.4.2 Cigarette lighters

The specific behavioral and constructional safety features required from cigarette lighters are set in two relevant International/European standards EN ISO 9994 - Lighters - Safety specification and EN 13869 Lighters. Child safety requirements for lighters. Safety requirements and test methods. Both of which are so called Harmonized European standards, meaning that the reference numbers of them have been published in the European Union official Journal. The standards therefore set the minimum safety requirements to be met.

4.4.2.1 EN ISO 9994 - Lighters - Safety specification

The (European adopted) international standard EN ISO 9994 deals with functional and constructional aspects of cigarette lighters. It sets the minimum safety level for several different aspects of the lighter.

The safety requirements for functional aspects deal with flame generation, flame height, flame height adjustment, resistance to spitting or sputtering and flaring and flame extinction.

From an individual consumers' point of view, probably the most important functional requirement regulates the ignition operation of the lighter. This requirement is also something everyone can test by themselves with relative ease before purchasing the lighter. Lighters should conform to (at least) one of the following requirements:

- a) positive action on the part of the user shall be required to generate and maintain a flame
- b) two or more independent actions by the user shall be required to generate a flame
- c) an actuating force equal to, or greater than, 15 N shall be required to generate a flame

The structural integrity requirements deal with external finishing, compatibility with fuel, resistance to fuel loss, resistance to dropping, resistance to elevated temperatures, resistance to internal pressure, burning behavior, resistance to cyclic burning and resistance to continuous burning

The standard also sets a minimum level of safety information that shall be given in the lighter. The information can be given in the form of text or symbols.

All lighters shall be marked at least with the following warnings:

“WARNING”

“KEEP AWAY FROM CHILDREN” or “KEEP AWAY OF REACH OF CHILDREN”

“Never expose to heat above 50 °C or to prolonged sunlight”

“CAUTION, RISK OF FIRE”

The corresponding symbols for the above-mentioned warnings are, respectively:



4.4.2.2 SFS-EN 13869 Lighters. Child safety requirements for lighters. Safety requirements and test methods

The European standard SFS-EN 13869 deals specifically with child safety aspects of cigarette lighters. It sets the minimum requirements for cigarette lighter regarding child safety. The standard states that no lighter shall be a child appealing lighter. By child-appealing it means that the cigarette lighter shall not be appealing to young children by its shape, sounds, lights etc. Furthermore, the standard dictates that the lighter shall be designed so that young children cannot operate it. The standard also specifies the requirements for the child proof ignition mechanism, which shall

- a) Reset itself automatically after each operation of ignition mechanism of the lighter,
- b) not impair safe operation of the lighter when used in a normal and convenient manner,
- c) be effective for the reasonably expected life of the lighter and
- d) not be easily overridden or deactivated.

4.5 Summary of current state analysis

The results from the questionnaire study provided quite a holistic view of the current consumer behavior amongst Finnish adult population. With the knowledge obtained from the study it became clear what the needs and wants of the consumers are, regarding product safety information and education.

Central findings of consumer behavior relevant to the development of the application:

- Almost 90 percent of consumers erroneously believe that authorities conduct pre-market inspections for consumer products.
- 64 percent of consumers fail to ensure the safety a product they are acquiring.
- The dangerous product registers are widely unknown.

- Consumers know the meaning of only the most common safety label symbols. Majority expressed a need for further education about the symbols.
- The respondents desired more easily available information about product safety. There was significant variation between different product groups.
- 70 percent of consumers would use or consider using a product safety check application, if one were available.

The current product safety components presented in the laws, regulations and standards of the chosen example context products are detailed, clear, comprehensive and relevant. However, most of the safety components presented in standards deal with issues that can only be checked by laboratories and are therefore somewhat irrelevant for consumers. For the product safety check tool, I will pick out those safety components that will help the consumer to recognise if a product might be dangerous.

5 Creation of the proof of concept version of the tool

In this section I will explain the phases of the application creation, and present the features, functions and product safety information created for the application.

5.1 Conceptual design

Based on the knowledge obtained from the literature review and from the questionnaire study, I set out to create a proof-of-concept version of the tool. The actual application coding was outsourced to Mr. Jami Pekkanen, as I oversaw the designing and functionality decisions, and created the information to be utilized in the tool.

The proof-of-concept version was developed using Framework7 library, from which the Android Material design interface was used. The usability aspects elicited in the literature review are built-in in the design of said library for most parts, therefore most of the detailed visual design aspects used in the development of the proof-of-concept version are not further explained in this section, even though the knowledge obtained from the literature review was used when developing the design.

Based on the knowledge obtained in the literature review and current state analysis, it was decided that the tool should have three key functions. The Product safety information section is based on the conceptual framework, and the Create notification and Notification check sections are based on the Current state analysis:

Create notification section where consumer can create and send notifications to Tukes about products they assume dangerous/non-compliant. Currently only about 14 percent of consumers report dangerous product to authorities. By making it easier for consumers to send reports to authorities, it should increase the share of consumers who report dangerous/non-compliant products to authorities instead of the seller.

Notification check section in which consumers can check if a product is notified as dangerous in Marek, Rapex or global Recalls. This section will also enable the consumer to register bought products, so that they will get a notification, if the product is deemed dangerous by authorities later. Only about 10 percent of consumers are currently aware of these registers. 80 percent of consumers would at least consider registering their bought products. By enabling consumers to get information about safety issues found in their purchased products, the unsafe products may be more efficiently removed from the use, supplanting the current methods used in product recalls. Most of the product recalls do not currently sufficiently reach the consumers as found out in the questionnaire study, see 4.2.1.

Product safety information section in which the most relevant information about how consumers can determine safety of a product and instruction for safe use would be given. Majority of consumers expressed desire for more easily available consumer product related safety information and reported that they would acquire more safety information's if it were more easily available (see section 4.2.3). This feature aims to fulfil this desire. The information content and presentation were designed based on the principles outlined in the conceptual framework.

The contents of the three key functions are explained in detail in chapters 5.3.1, 5.3.2 and 5.3.3 respectively.

The conceptual framework's (see section 3.5) four different elements; Information, Education, (application) Functional design and (application) Visual design recognized to affect the usability of a safety education mobile application were incorporated in the proof-of-concept version of the application.

5.1.1 Information and Education

The product safety information was created based on the needs of consumers and the relevant safety components derived from the laws, regulations and standards. The information was decided to be mostly based on the safety warnings; as the example context products are inherently dangerous, it is of utmost importance that consumers understand and follow the safety warnings. Based on the knowledge obtained in the literature review, the safety information was decided to be also explanatory, as simply warning doesn't have as much effect on the behavior (see sections 3.3 and 3.4).

Even though research suggests that the more information is given to consumer, the more effect it has on the behavior, it was decided that the application has only short warning information sections. This is due to the intended place of use of the application; it is highly likely that consumers wouldn't read extensive warnings and information explanations while in store for example.

The safety information and the presentation of the information is shown in section 5.3.3.

5.1.2 Functional design

The application was created as a so-called web application using HTML 5 technologies. This way the application is also reachable via a website, and therefore has a wider entry point selection than a native or hybrid application would have. A wider entry point selection permits a wider audience. Using the web application approach, users don't need to download the application, but can simply use it via browser, yet it has all the functionalities and design of a native/hybrid application. The only difference is that users must be online for the application to work. This, however shouldn't be an issue, as most mobile device users in Finland has unlimited internet use in their mobile broadband contracts.

The application was decided to have a highly hierarchical tree-like structure. Only essential controls were incorporated to avoid having to use complex menu structure and in-app search function all together. This highly hierarchical structure implicitly guides the user navigate around the application, as discussed in section 3.1.8. If the user can only move back and forward within the application structure, they shouldn't end up having difficulties to navigate to and from the desired functions.

The overall structure was kept simple and avoided heavy multimedia elements, such as automatically loading videos and large images, to optimize the loading time and responsiveness as suggested in section 3.1.11.

Due to the intended use of the application in mobile environments, such as stores, it was deemed that the user should be able to see as much information in one screen as possible. Because of this, the product safety information sites were designed so that the main message will appear in the main site, and the explanatory text will open by touching the relevant box in the site. The explanatory text will open in a dropdown menu style, leaving most of the original main site information readable. This way the user can simultaneously glance most of the main information and see the explanatory text of the chosen information.

5.1.3 Visual design

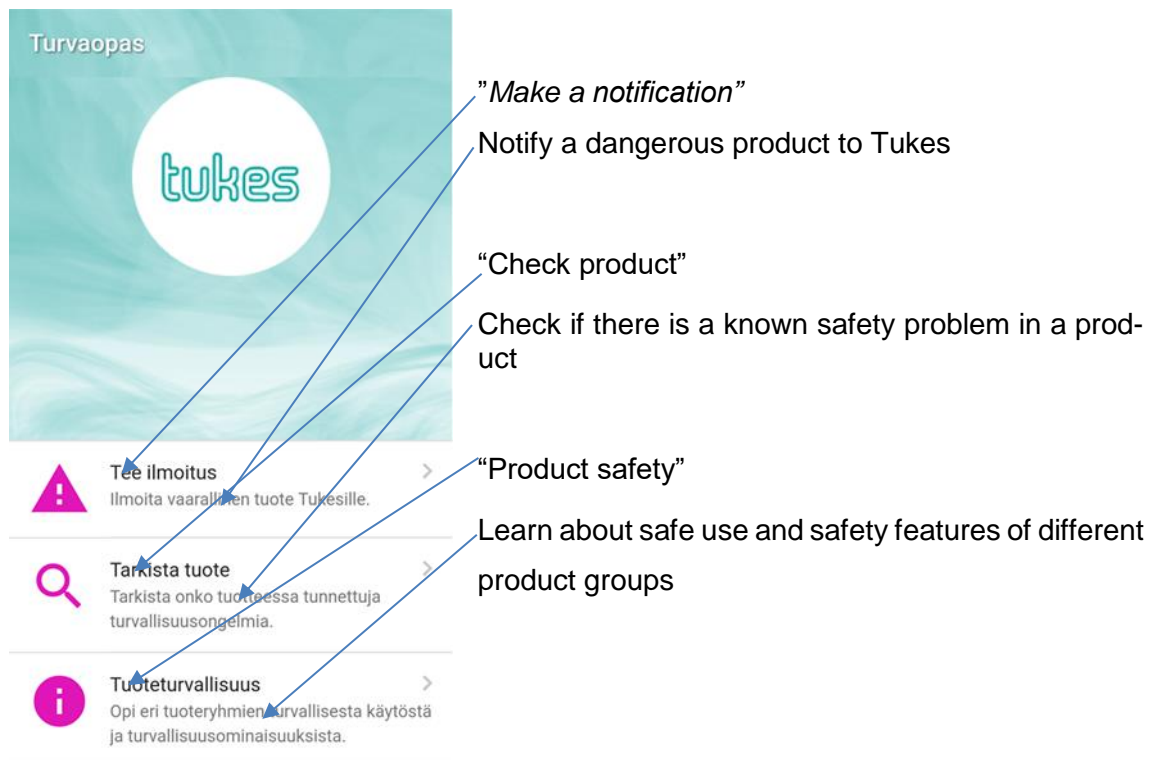
The simple menu structure explained in the previous section also minimized the number of control buttons in each view, which in turn enabled the usage of large buttons, stretching throughout the whole horizontal space of the screen. Such relatively large buttons are important for usability, especially on touchscreen mobile devices (see section 3.1.5).

The color scheme was chosen to be that of Tukes' official colors, pink and turquoise. These colors provide quite a good contrast which is important for the interface's appeal and readability as discussed in section 3.1.2. The Tukes color scheme also creates an aesthetic scheme easily connected to Tukes by the user.

To aid users to recognize the application from all the other application shortcuts in their mobile device a simple, yet noticeable shortcut icon was created.

5.2 The proof-of-concept version of the application

The poof-of-concept version of the application is illustrated in this section. The Main menu is illustrated below.



5.2.1 Create notification

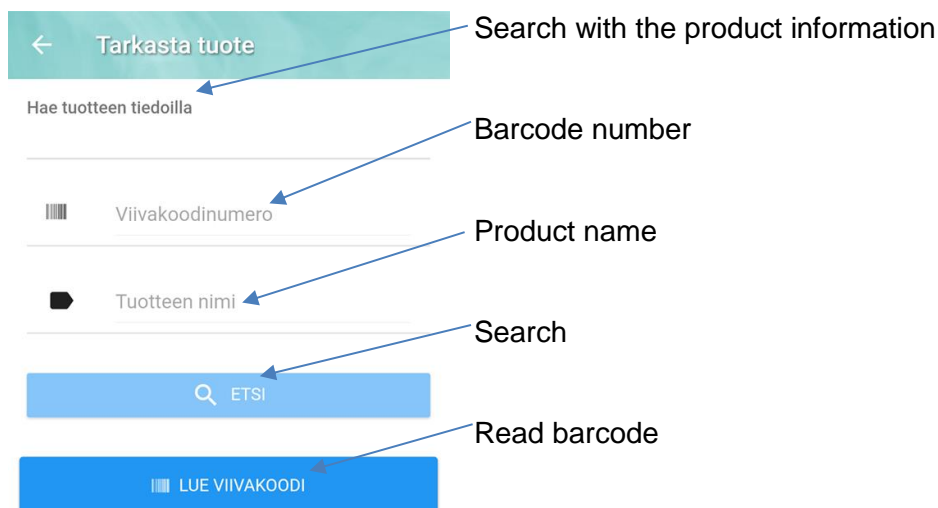
Through the Create notification function, consumers can easily send notifications to Tukes about products they suspect to be dangerous or non-compliant. In this function the consumer can fill in all information relevant in market surveillance purposes. The function was designed to not too many fields or too exact information, so the consumers will find it easy and worthwhile to fill all the fields and send the notification. The consumers also have the possibility to select image from mobile device directory or taking photo with the mobile application camera via built-in camera function.

The screenshot shows a mobile application form titled 'Tee ilmoitus' (Make report). The form is divided into several sections, each with a label in English pointing to a specific field:

- Product information**: Points to the 'Tee ilmoitus' header.
- Product name**: Points to the 'Tuotteen nimi' field.
- Place of purchase**: Points to the 'Ostopaikka' field.
- Photos of the product**: Points to the 'Tuotteen kuvat' section, which includes a 'Valitse tiedosto' (Select file) button and the text 'Ei valittua tiedostoa' (No file selected).
- Description of the problem**: Points to the 'Ongelman kuvaus' field.
- Your contact information**: Points to the 'Yhteystietosi' (Your contact information) section.
- First- and surname**: Points to the 'Etu- ja sukunimi' field.
- E-mail address**: Points to the 'Sähköpostiosoite' field.
- Phone number**: Points to the 'Puhelinnumero' field.
- Send notification**: Points to the 'LÄHETÄ ILMOITUS' (Send report) button.

5.2.2 Notification check

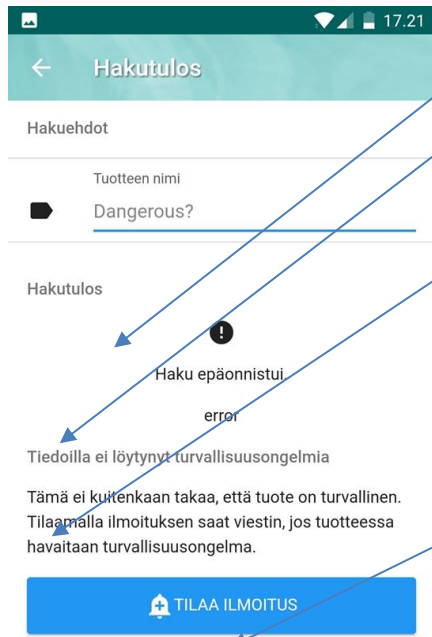
This function gives users the ability to check if any individual product has been deemed dangerous by officials and is notified to consumers in Marek, Rapex or Global recalls. In the proof-of-concept version, only Rapex directory can be checked. The function provides two different means to search notifications; By product name and by barcode. The barcode search can be conducted either by typing in the barcode number, or by scanning a barcode in a product using the built-in barcode reader.



If the product is found in the directory, the application will open a link to the relevant notification in the Rapex (and in future Marek and Global Recalls) for further instructions to the consumer.

Furthermore, if the product is not found in the directory, the application will return a message stating that “The product was not found in the directory, but that does not guarantee that the product is safe. By ordering a notification, you will receive a message if the product is deemed as dangerous/non-compliant in the future.”

If the consumer registers the product to the application and leaves their contact details (phone number or e-mail address), they will get a notification if the registered product shows up in the directory.



Search results

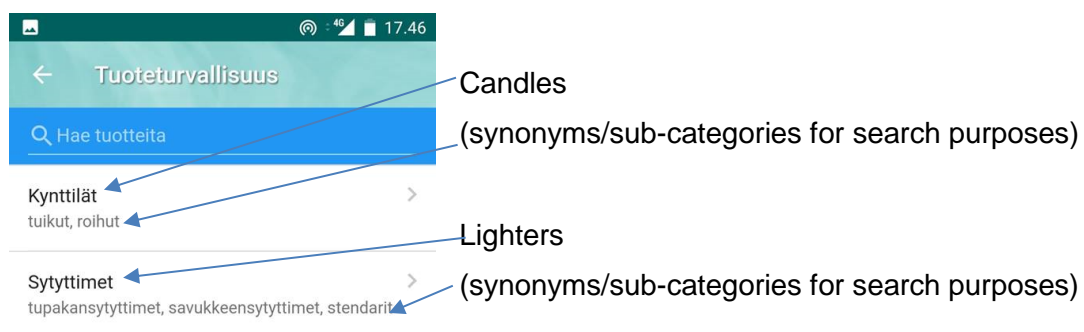
No product safety issues found with the information

This, however, doesn't insure that the product is safe. By ordering a notification, you will receive a message if the product is found to have safety issues

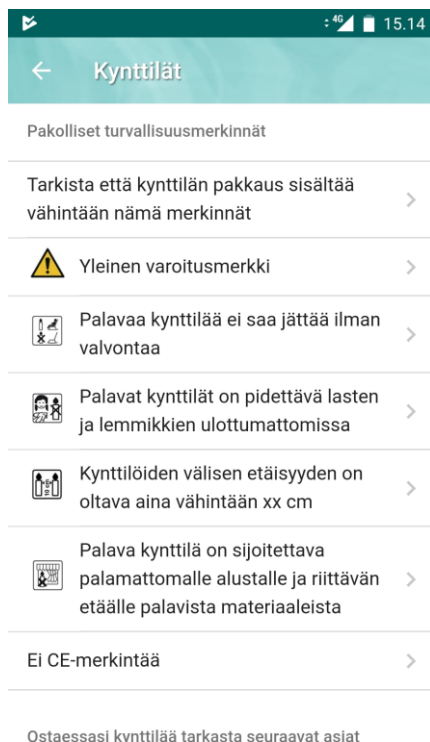
Order notification

5.2.3 Product safety information section

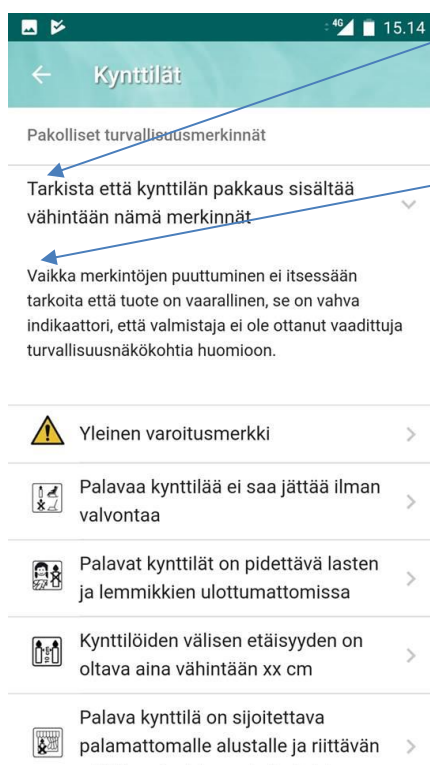
The product safety information section consists of several “product sites” where most important safety aspects of the products are explained. Each “warning” stated in the site also includes an explanation of the specific danger the warning is for.



5.2.3.1 Candles

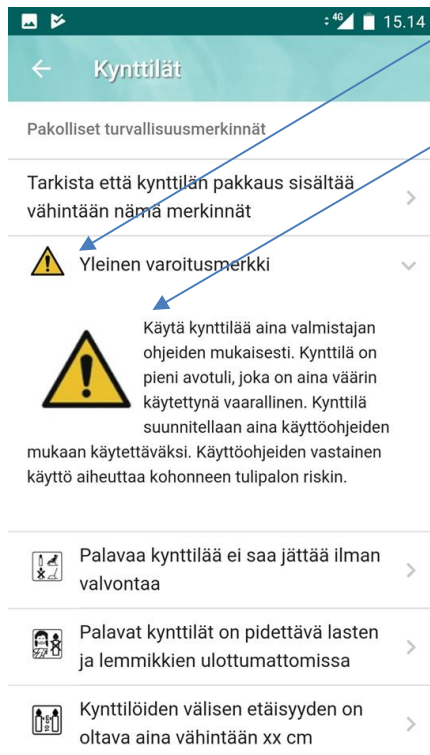


When touched, the text box opens and reveals a text explaining the reasoning behind the “warning”.



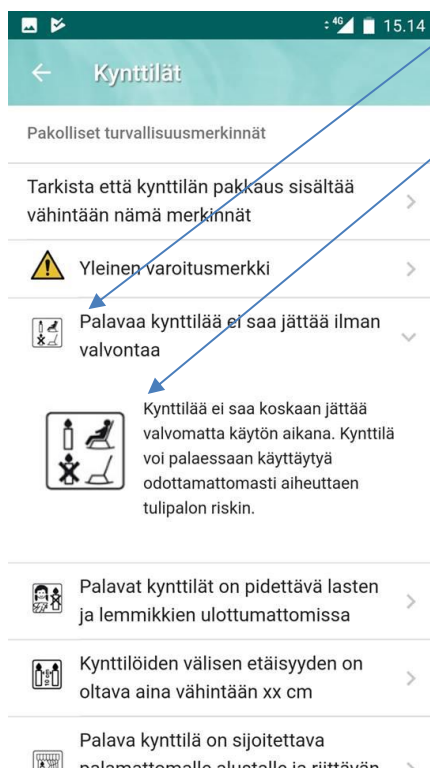
“Check that the candles packaging includes at least the following markings”

Even though the absence of the safety markings does not automatically mean the product is dangerous, it is a strong indicator that the manufacturer of the product may not have taken into account the required safety aspects.



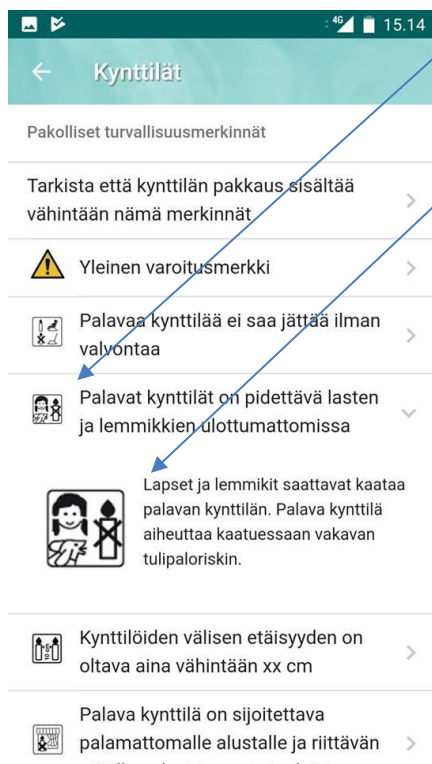
“General warning symbol”

Always use the candle according to the manufacturer's guidance. Candle is a small open fire which is always dangerous when used inappropriately. Candles are always designed to be used according to the guidance. Using the candle against the guidance always causes an elevated risk of fire.



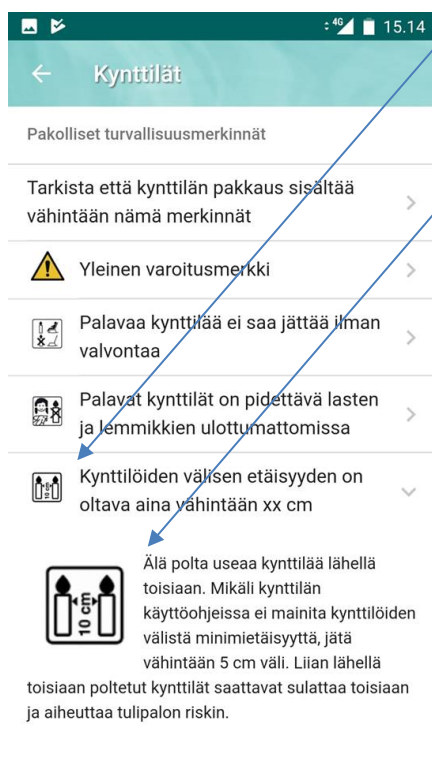
“Do not leave burning candle unattended”

Never leave candle unattended during use. Candle may behave unexpectedly while burning, causing a risk of fire.



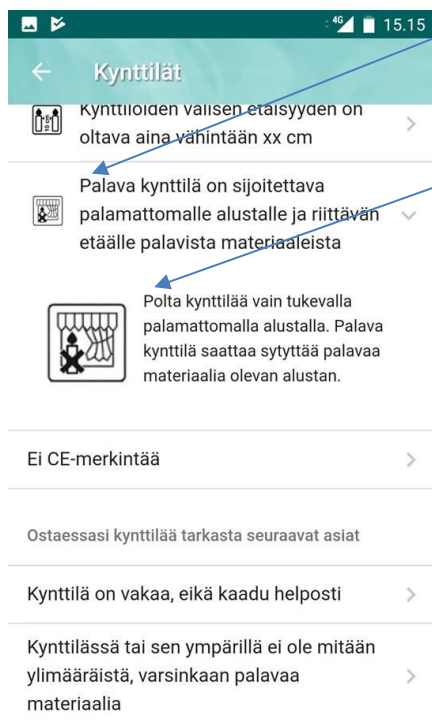
“Burning candles shall be kept away from children and pets”

Children and pets may tip over the burning candle. A burning candle causes a severe risk of fire if tipped over.



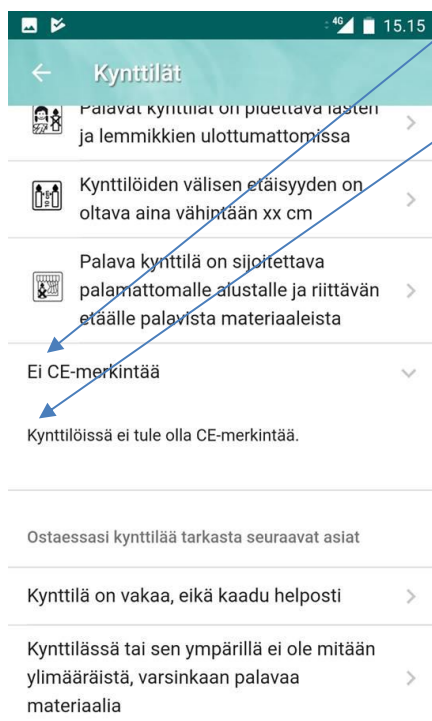
“The distance between candles shall always be at least xx cm.”

Do not burn candles close to each other. If the candle's guidance doesn't mention the minimum distance between candles, leave at least a 5 cm gap. Candles burning too close to each other may melt each other and cause a risk of fire.



“Burning candle is to be placed on non-combustible surface and far enough from combustible material”

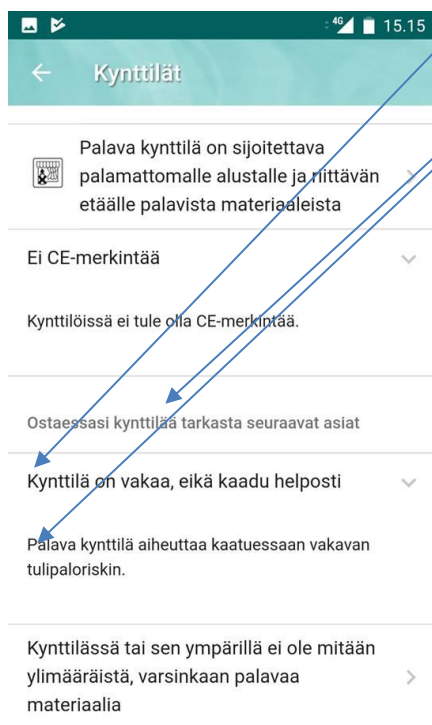
Burn candle only on a rigid non-combustible surface. A burning candle may ignite combustible surface materials.



“No CE-marking”

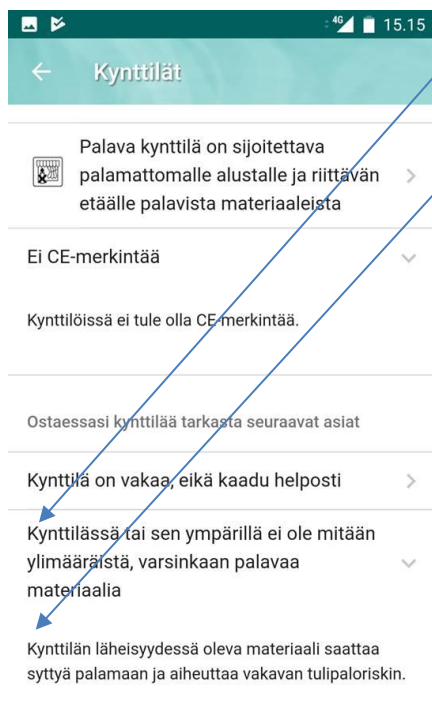
Candles shall not bear a CE-marking.

The last two information texts are to give a guidance to the consumer on what to look for in a candle prior to purchasing. The heading reads: "When purchasing a candle, check the following aspects".



"Candle is stable, and does not tip over easily"

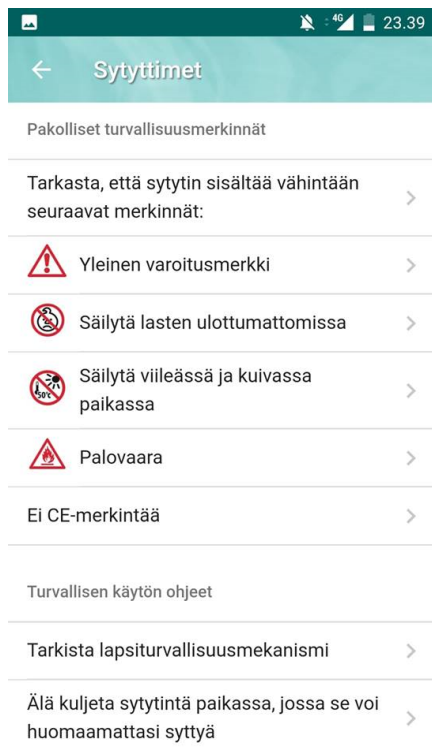
Burning candle causes a severe fire risk if it tips over.



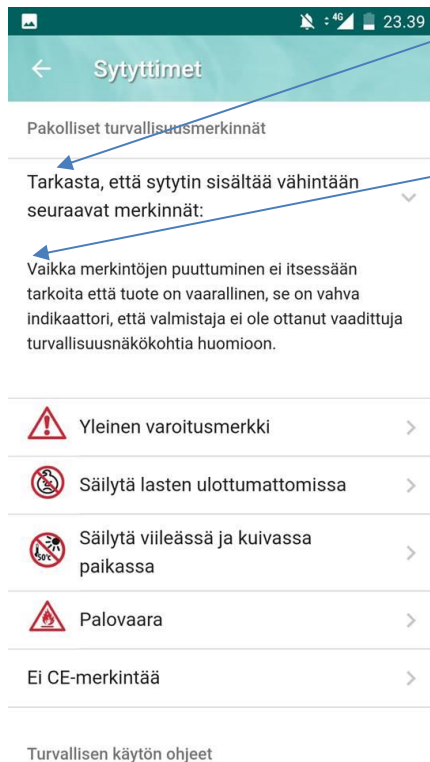
“In or around the candle there isn’t any extra, in particular, combustible material”

Material in close proximity to the candle may ignite and cause a severe risk of fire

5.2.3.2 Cigarette lighters

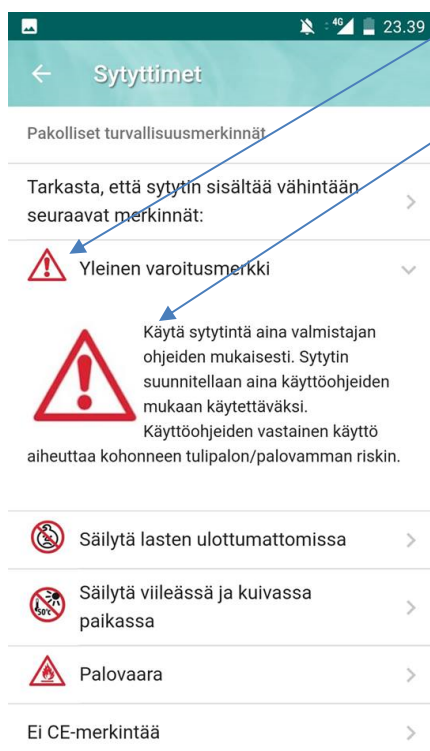


When touched, the text box opens and reveals a text explaining the reasoning behind the “warning”.



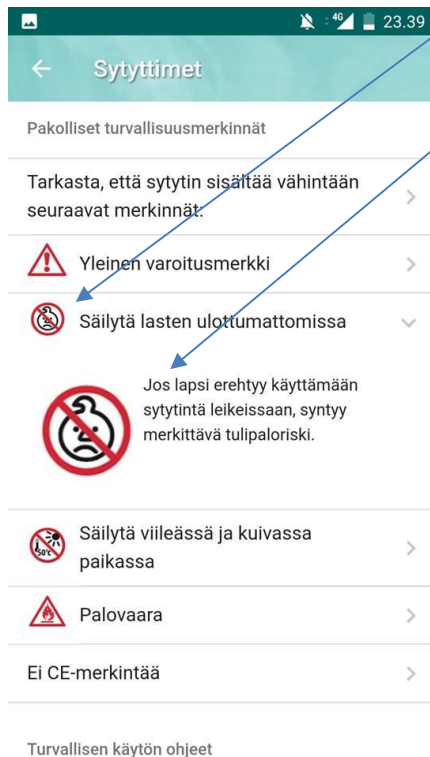
“Check that the lighter includes at least the following markings”

Even though the absence of the safety markings does not automatically mean the product is dangerous, it is a strong indicator that the manufacturer of the product has not taken into account the required safety aspects.



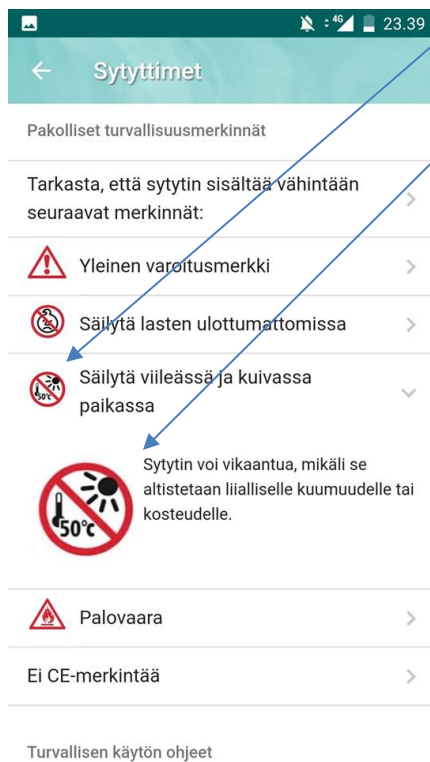
“General warning symbol”

Always use the lighter according to the manufacturer's guidance. Lighters are always designed to be used according to the guidance. Using the lighter against the guidance always causes an elevated risk of fire/burns.



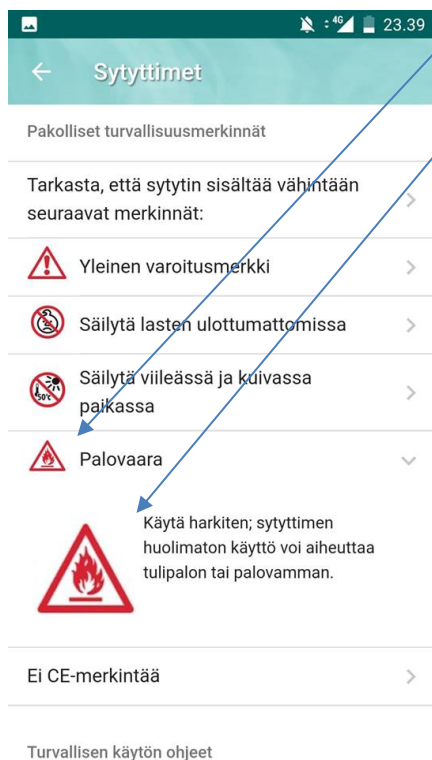
"Keep away from children"

If a child mistakenly uses a lighter while playing, it causes a high risk of fire.



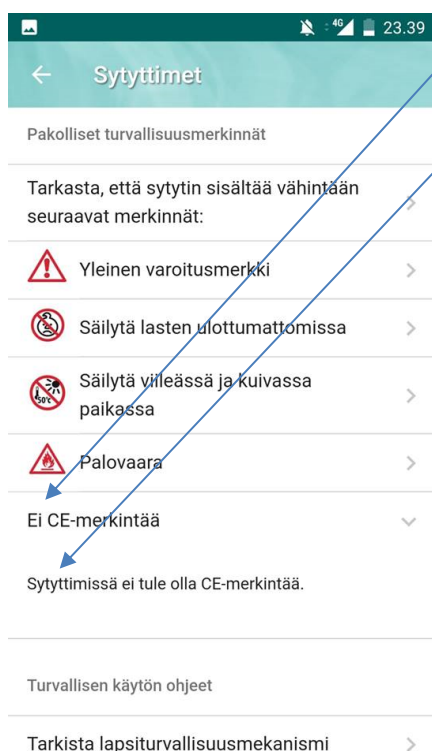
"Store in cool and dry place"

The lighter may malfunction if exposed to elevated temperatures or moisture.



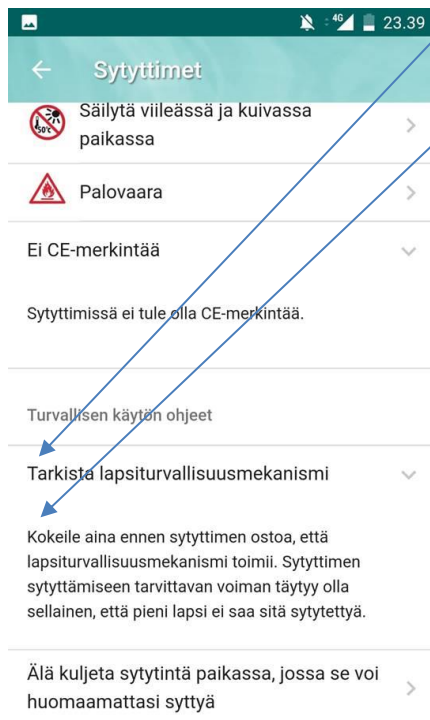
"Risk of fire"

Use judiciously; negligent use of a lighter can cause a fire or burns.



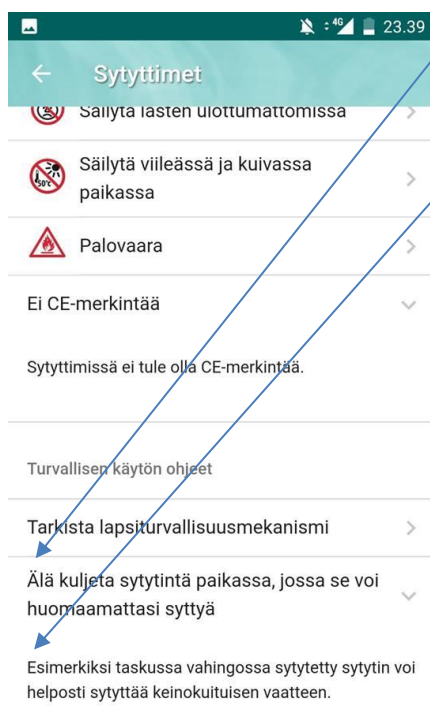
"No CE-marking"

Lighters shall not bear a CE-marking.



"Check child safety mechanism"

Always test that the child safety mechanism of the lighter works before purchasing. The force needed to operate a lighter shall be great enough that a small child cannot operate the lighter.



"Do not carry a lighter in a place where it can ignite accidentally"

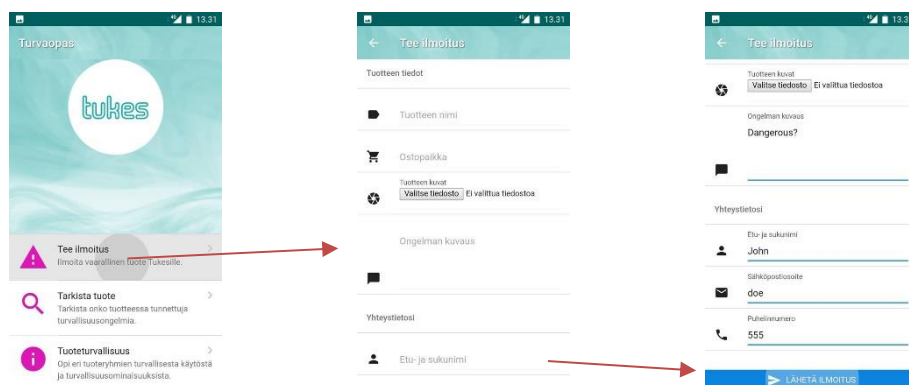
For example, if a lighter accidentally ignites in a pocket, it can easily ignite clothing made of synthetic fiber.

5.3 Summary of application development

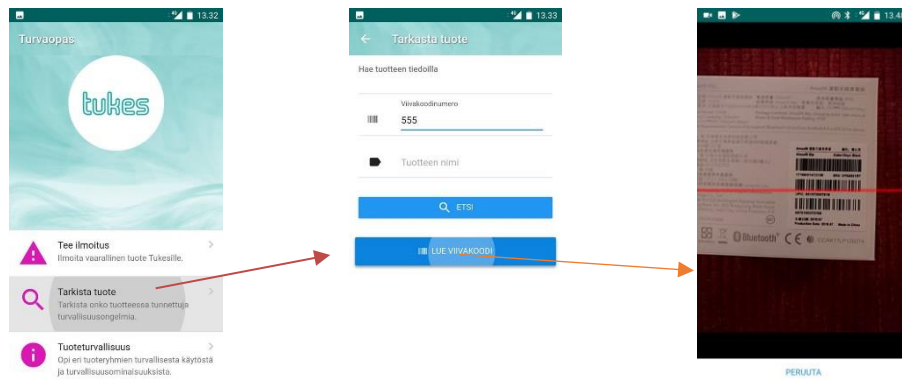
The proof-of-concept version of the consumer product safety check tool developed in this research project consists of three functions, aimed to assist consumer to recognize safety hazards of consumer products, check if authorities have deemed a product dangerous or non-compliant and lastly make notifications to Tukes on products they suspect a product being dangerous or non-compliant.

The application has a simple highly hierarchical tree-like structure, where users only move back and forward from the main menu while using the function.

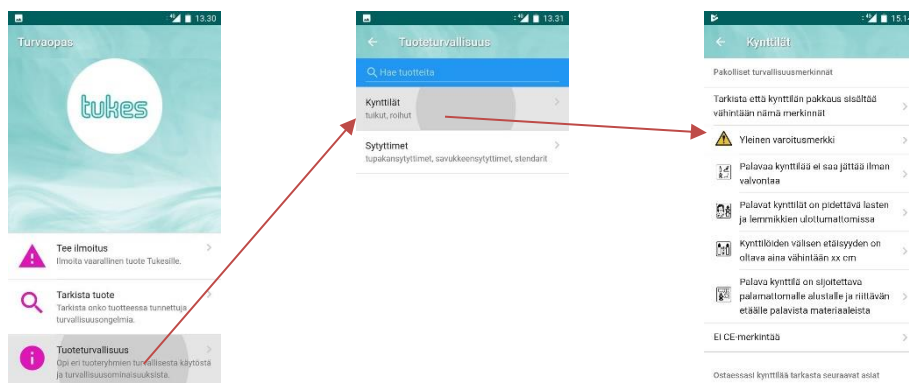
The “Make a notification” section presented below is a simple three step function where the user first pushes the “Make a notification” -button, which opens the notification sheet, the user then fills the field and push the “send notification” -button. The notification gets sent directly to Tukes.



The “Notification check” function illustrated below also works in three simple steps. The user pushes the “Notification check” -button which opens the search function menu. In the search function menu the user can choose to search for notifications either by entering product name or barcode, or by reading a barcode of a product using the built-in barcode reader. The application then searches authorities’ databases (only Rapex in the proof-of-concept version) for the product, and presents a link to the notification if one is found. If the product is not found the application provides a possibility for the consumer to enter their contact information to which a notification is sent if the product is deemed dangerous or non-compliant by authorities later.



The "Product safety information" section, presented below, is entered into by pushing the "Product safety" -button in the main menu. All the product types of which a safety information sheet has been created are shown in the list. The user can find the desired product either by scrolling the list or by using the in-app search function. To enter to the safety information sheet of the desired product users need to simply push the relevant product name in the list.



6 Small scale product validation

The small-scale product validation was conducted by asking 7 subjects (market surveillance experts from Tukes' consumer product unit) to familiarize themselves with the application for a period of three days. The subjects were also asked to prepare to discuss about the application, especially about usability, the three functions, design and the context and presentation of the product safety information. After the try-out period a 30-

minute open discussion session about the application was held. The discussion was recorded, and the content of the discussion was analyzed using the framework analysis method.

6.1 Feedback from Single Focus Group discussion

The discussion revolved mostly around technical issues, as the design, usability and functionality were to everyone's liking. The overall application was described with words like "Nice, well-functioning, easy to use," etc. The technical issues raised concerned the "Create notification" and "Notification check" functions. There was a mutual concern among the participants that, with the current functions, Tukes might receive large volumes of false notifications. The concern arose from both "Notification check" and "Create notification" functions. In the "Create notification" function, the participants felt that detailed enough information about the product wasn't asked. It was suggested that more fields should be added to the function, asking more detailed information, such as product brand name, serial number, barcode etc. This is because if the notification doesn't include detailed information about the product notified, it is impossible for Tukes to investigate the issue further. The other concern arose from the "Notification check" function's vague definition of "Product name" in the search field. Should the user use a brand name in the search, and receive a bunch of notifications, they could mistakenly think that their specific product under the brand name was dangerous and send a notification to Tukes. This could also be avoided by adding more specific search fields to the function.

Some participants also pointed out that consumers would probably stop using the "Notification check" function after a while if their searches fail to find any notifications. This issue was thought in advance, and due to this foreseen issue, the possibility to register products as bought to receive notification possibly later about the product was added to the function. This function wasn't known by the subjects beforehand.

The product safety information section was very well welcomed. The consensus was that it is probably the most interesting part of the application. The type of information and the presentation of the information received mostly positive feedback. The only critique/development proposal was that it would be better if the warning symbol texts would be presented after the more guiding information, as the participants felt that consumers would be more interested in the later.

The participants also felt in unison that the application should have built in guidance about how to use the functions.

In the end of the discussion session the consensus was that the proposed application would be useful and that its development should be continued.

6.2 Proposals for further development

The participants also suggested several proposals for further development for the application. For example, it was proposed that the application could be modified to be used by Tukes' field inspectors as a product check tool. Tukes' field inspectors roam around the country in shops, looking for products that are forbidden to sell.

Another development proposal was that the application could "double" as a product safety pictogram image bank where all pictograms used in products would be stored with the explanation of the meaning of the pictogram.

7 Discussion and Conclusions

7.1 Summary

The need for this type of medium for consumer education became apparent during the research as both the consumers as well as market surveillance authorities recognized the importance of easily available product safety information.

This research has set out a blueprint for creating a functioning mobile application for providing product safety related information and education material, as well as enabling consumers to easily check if a product has been deemed dangerous or non-compliant by authorities and send notifications to authorities of products they suspect being dangerous or non-compliant.

The suggested type of information and the type of information presentations was developed based on earlier research about safety education and safety information effectiveness factors. However, due to the limited research on those fields as discussed in section 3, it is not conclusive that the suggested information yields the best possible outcome on

consumer behavior, thus the effectiveness of the application shall be subjected to continual follow-up studies and the application shall be constantly modified based on the results of the knowledge obtained.

The “Make notification” and “Notification check” functions were designed based on both consumers’ and Tukes’ needs. The needs are however not perfectly aligned, so some compromises had to be made. For example, in the amount of detailed product information to be entered to a notification was reduced to a bare minimum from Tukes’ point of view, to make the sending of notifications as simple as possible for consumer. The focus group raised concerns that this may (see section 6), however, lead to Tukes receiving excessive amounts of notifications with too limited product information for market surveillance purposes. These types of details can’t be engineered without further data on user behavior. Therefore, these details have to be perfected later based on experiences gained after the application is launched to consumer use.

7.2 Next practical steps towards implementation of the application

The outcome of this study, the proof-of-concept version of the mobile application, needs to be further developed before launching it for consumer use. Based on the replies from the questionnaire study, consumers feel they mostly need product safety related information about product groups they feel poses a danger, such as home appliances, gas appliances and power tools. It is of utmost importance to incorporate the safety information of those product groups to the application because it is highly likely that consumers won’t use the application if it doesn’t contain the information they are seeking.

Therefore, the next practical step is to create a number product safety information sites involving several different products from several different product groups, after which a pilot version of the application can be developed.

In the pilot version development also the suggestions from the focus group discussion shall be more closely examined and the application shall be modified accordingly.

7.3 Evaluation of thesis trustworthiness

The trustworthiness of this research was evaluated by assessing all the sub-elements of the four criteria presented by Shenton (2004); credibility, transferability, dependability

and conformability. The assessment is presented in four separate tables below, which represents a modified Shenton's assessment table.

Credibility

Measures of credibility	Applicability in this research
Adoption of appropriate, well recognized research methods	Qualitative research method applied was in the form of an open discussion session, of which the recordings were analyzed using the framework analysis method. The quantitative questionnaire study was commissioned from the leading quantitative questionnaire company.
Development of early familiarity with culture of participating organizations	All parties participating to the development are employees of the case organization.
Random sampling of individuals serving as informants	Not applied. All the individuals serving as informants in the qualitative discussion session were selected to be experts in the field of product safety and market surveillance. The questionnaire used the sampling method of the contractor company.
Triangulation via use of different methods, different types of informants and different sites	The study used both the qualitative open discussion session of domain experts and the qualitative questionnaire study representative of Finnish adult population.
Tactics to help ensure honesty in informants	In the qualitative open discussion session, the researcher only provided the general focus the discussion, and let the

	participants discuss freely. The questions for the quantitative questionnaire were developed together by the researcher and a professional from the contractor company.
Iterative questioning in data collection dialogues	Not applied.
Negative case analysis	Not applied.
Debriefing sessions between researcher and superiors	The on-going work was presented multiple seminars and in contact sessions with the thesis supervisor.
Peer scrutiny of project	The proof-of-concept application was given to all employees of Tukes' Products Department for open critique.
Use of "reflective commentary"	See section 7.1 for a brief reflective commentary.
Description of background, qualifications and experience of the researcher	Not applied.
Member checks of data collected, and interpretations/theories formed	Not applied.
Thick description of phenomenon under scrutiny	The general phenomenon of consumer behavior and understanding regarding product safety is described in sections 3.3 and 3.4.
Examination of previous research to frame findings	A review of existing knowledge shown in section 3.1, 3.2, 3.3 and 3.4 and framed in section 3.5 into a conceptual framework.

Transferability

Measures of transferability	Applicability in this research
The number of organizations taking part in the study and where they are based	Only one organization took part, because the application developed was aimed at this single organization.
Any restrictions in the type of people who contributed data	The quantitative data was gathered from the Finnish population. The qualitative data was collected only from individuals working in the case organization.
The number of participants involved in the fieldwork	1012 respondents in quantitative questionnaire study. 7 participants in the open discussion session.
The data collection methods that were employed	Open discussion session, quantitative questionnaire study (Kantar TNS internet panel)
The number and length of the data collection sessions	One 30-minute open discussion session. Internet panel answers were gathered during one weekend.
The time period over which the data was collected	The discussion session took place 20.9.2018. The questionnaire study took place 5-6.5.2017.

Dependability

Measures of dependability	Applicability in this research
The research design and its implementation, describing what was planned and executed on a strategic level	Detailed description in section 2 of this thesis.
The operational detail of data gathering, addressing the minutiae of what was done in the field	See section 2.2

Reflective appraisal of the project, evaluating the effectiveness of the process of inquiry undertaken.	Not applied.

Confirmability

Measure of confirmability	Applicability in this research
Triangulation to reduce the effect of investigator bias	Not applied.
Admission of researcher's beliefs and assumptions	Not applied.
Recognition of shortcomings in study's methods and their potential effects	See section 7.1.
In-depth methodological description to allow integrity of research results to be scrutinized	See section 2.
Use of diagrams to demonstrate "audit trail"	See Figure 1 and Table 1.

The evaluation shows that the study fulfills most of the criteria outlined by Shenton (2004), however, as this study comprise both quantitative and qualitative elements and a product development process, some of the Shenton's criteria are not relevant to this research project.

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